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WIRELESS SENSOR NODE

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What is Wireless Sensor Node?

- Wireless sensor (WS) node is the basic unit of any wireless sensor network (WSN)
- A number of sensor nodes distributed within the application area and communicating with each other using radio-frequency signals constitute a wireless sensor network
- It is an embedded system.
- It is a programmable device.

Functions of WS Node

1. Sensing
2. Data acquisition
3. Data processing
4. Data storage
5. Wireless (radio-frequency) communication
6. Data networking

Design Requirements of WS Node

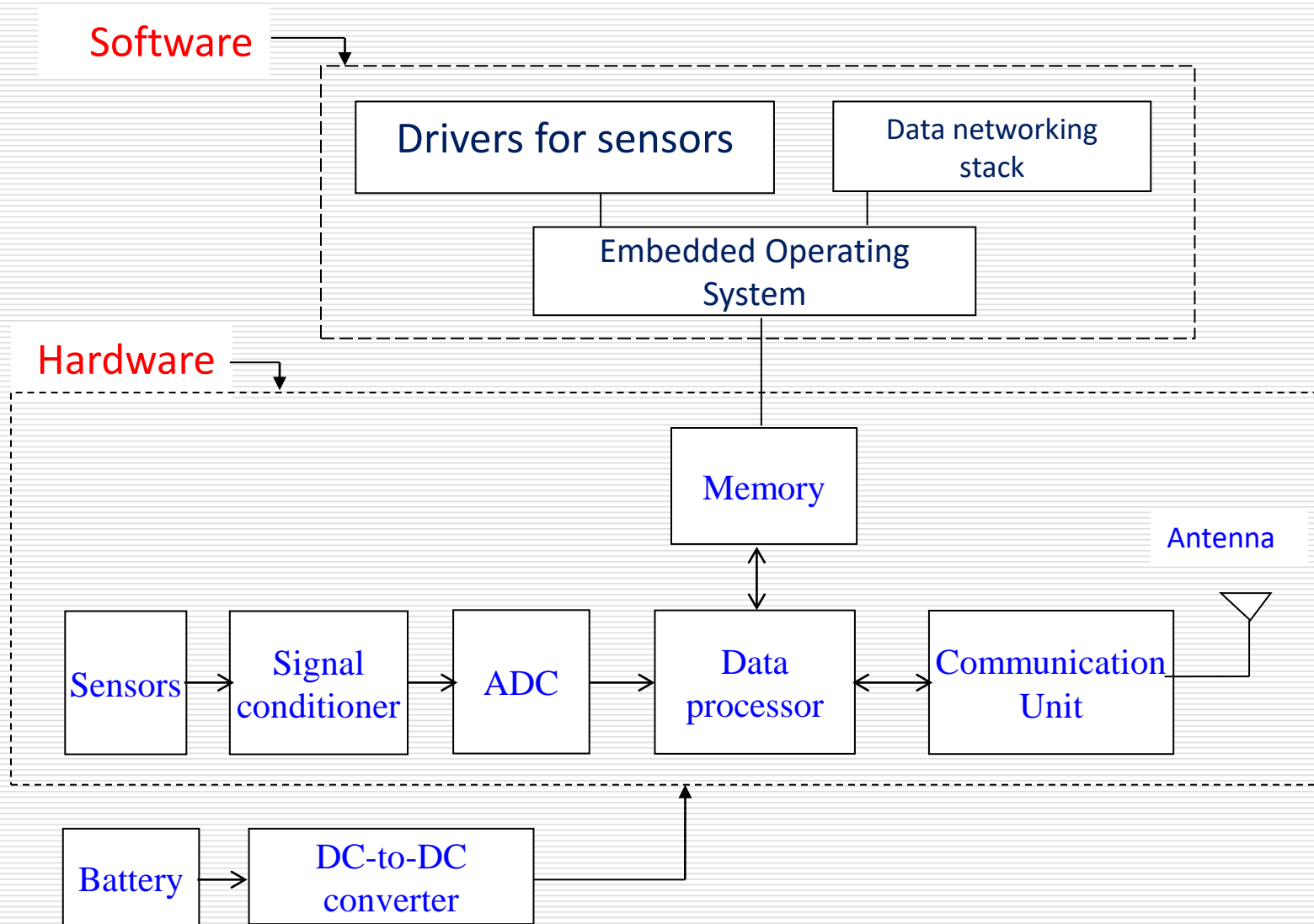
Typical design requirements or specifications of a wireless sensor node are:

1. Sensing capability
2. Some data processing capability
3. Some data storage capacity
4. Unlicensed radio-frequency-band communication capability
5. Low power consumption
6. Small size
7. Low cost

Architecture of WS Node

- WS node consists of embedded hardware and software components
- The hardware comprises five units:
 1. Sensors
 2. Data acquisition unit (DAQ unit)
 3. Data processing unit (DPU)
 4. Communication Unit
 5. Power supply unit (PSU)
- The software comprises three modules:
 1. Operating system
 2. Drivers for sensors
 3. Data networking stack

Typical Architecture of WS Node



Hardware Component-1: Sensors

- Sensors form the front end of a WS node
- They sense real-time physical variables and produce analog electrical signals as the outputs
- Generally, smart sensors (characterized by inbuilt signal conditioning circuits, small size and low power consumption) with standard analog/digital output are preferred over conventional sensors.

Hardware Component-2: DAQ Unit

- DAQ unit (data acquisition unit) is comprised of signal conditioner and analog to digital converter(ADC)
- Signal conditioner processes or conditions the analog electrical signals obtained from sensors to make them compatible with the ADC
- The conditioned analog signals are then converted to equivalent digital signals by a multi-channel ADC
- If a smart sensor (rather than a conventional sensor) with conditioned analog output is used, then further signal conditioning may not be required for that sensor
- If a smart sensor with digital output is used, then even ADC is not needed for that sensor.

Hardware Component-3: DPU

- DPU (data processing unit) comprises data processor and memory
- Data processor is a device that processes the data and controls the operation of other components (DAQ unit, memory and RF transceiver) in the node
- It acquires data from various sensors of the node, processes this data and decides when and where to send it
- It executes various programs.
- Data processing device is a microprocessor, microcontroller, programmable digital signal processor (DSP), field-programmable gate array (FPGA) or an application-specific integrated circuit (ASIC). Choice among them is made on the basis of (a) flexibility, (b) performance, (c) energy efficiency and (d) cost.
- Small size (4kB or so) RAM is used to store the incoming data and intermediate results of computation
- EEPROM or flash memory is used to store program code.

Hardware Component-4: Comm. Unit

- Communication unit comprises radio-frequency (RF) transceiver and antenna
- It is used to transmit/receive data to/from other nodes and gateway node
- It converts the bit-stream coming from the DPU to RF signals, and vice versa
- **Transceiver:** (a) Low-cost, (b) low-power, (c) short-range, (d) ISM-RF-based, (e) having energy-saving states, and (f) operating in half-duplex mode.
- Issues related to the physical layer, medium access control (MAC) and network layer are considered while designing the transceiver.

Hardware Component-5 : PSU

- PSU (power supply unit) feeds power to all other units of the node
- It is a crucial component of WS node as it decides the life of the node
- PSU is usually comprised of a battery followed by a DC-to-DC converter
- **Battery:** Should be of (a) adequate capacity, (b) high energy density, (c) small weight, and (d) low self-discharge rate.
- In some cases, **rechargeable battery** has been used along with photovoltaic (PV) solar cells
- **DC-to-DC Converter:** For changing and regulating voltage as per the need of other units.

Software of WS Node

- Software is an important architectural element of a WS node as it drives the node hardware.
- The node software should have the following functionalities:
 - a. Data acquisition
 - b. Digital signal processing
 - c. Computations
 - d. Data compression
 - e. Error control
 - f. Encryption
 - g. Data communication
 - h. Network routing
- The software has several modules and their complexity can vary widely; major ones discussed here.

Software Module-1: Operating System

- The operating system is an essential software as it provides the framework for developing any application and relieves the developer from machine-level functionality of the microprocessor.
- It is also used by all other software modules to support various functions.
- Desirable features of the operating system:
 - Should be small in itself
 - Should enable rapid implementation
 - Should ensure minimum application code size because of memory constraints in sensor nodes.

Software Module-2: Drivers

- Drivers for the onboard sensors.
- This software module supports various functions of the onboard sensors.
- It facilitates configuring and changing the settings of onboard sensors.
- It insulates the application software from the machine-level functionality of the sensors.

Software Module-3: Data Networking Stack

- This software module implements data communication on wireless network.
- Typically, the following five layers of the seven-layer OSI model are included in the data networking stack of WS node:
 - i. Application Layer (L-7)
 - ii. Transport Layer (L-4)
 - iii. Network Layer (L-3)
 - iv. Data Link Layer (L-2)
 - v. Physical Layer (L-1)